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TITLE: Apparatus for membrane separation

Abstract Text (1):
A module of membranes for permeatingly treating fluid to be treated is housed in a pressure vessel, and, in this pressure vessel, a device for feeding the fluid to be treated is integrally connected to this pressure vessel. The pressure vessel has devices for taking the permeated fluid and the thickened fluid out of the module, respectively.

Brief Summary Text (2):
This invention relates to an apparatus for membrane separation, and more particularly to an apparatus for membrane separation, wherein a driving section and a membrane separating section are directly connected to each other to thereby obtain an apparatus for membrane separation facilitated in the handling, transportation and installation.

Brief Summary Text (3):
In recent years, in water treatment field for liquids containing various inorganic and organic materials, such as waste water treatment, conversion of sea water into plain water and production of pure water, there have been widely used apparatuses for membrane separation each incorporating therein ultrafiltration membranes, reverse osmosis membranes or selective permeation membranes including precision filtration membranes or the like, i.e. an apparatus for ultrafiltration, an apparatus for reverse osmosis membrane separation and the like.

Brief Summary Text (4):
In general, the apparatus for membrane separation of the type described comprises a pressure vessel incorporating therein selective permeation membranes such as reverse filtration membranes, a high pressure pump for feeding a stock solution under pressure to the stock solution feeding chamber of the pressure vessel, a blower, a vacuum pump, a motor for driving the pump, a piping provided therearound, valves, gauges, an electric instrumentation system and so on.

Brief Summary Text (5):
Since, in the conventional apparatus for membrane separation, a membrane separating section, wherein only selective permeation membranes are incorporated in a pressure vessel, a pump for feeding a stock material, a blower and a driving section such as a starting motor are connected to one another through a piping, the following disadvantages have been presented.

Brief Summary Text (6):
(1) The apparatus as a whole becomes large-sized.

Brief Summary Text (8):
(3) It is difficult to manufacture, transport and install the apparatus.

Brief Summary Text (9):
(4) Multiplicities of pipings, valves, gauges, frames and the like are needed and the arrangement of apparatus is complicated.

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Brief Summary Text (10):
(5) When the apparatus is used as a plant or a part of plant, each of the component parts must be designed and the required assembling operation is complicated.

Brief Summary Text (11):
(6) It is not easy to select the materials of the pipings, valves and the like and to set up the sizes thereof, and, mistakes in selection and setup of the materials may lead to the physical deterioration of the selective permeation membranes.

Brief Summary Text (14):
An object of the present invention is to provide an apparatus for membrane separation, wherein the installion area can be minimized due to the simplified arrangement and the transportation and installation works are facilitated.

Brief Summary Text (15):
Another object of the present invention is to provide an apparatus for membrane separation, wherein the operation control is easily effected.

Brief Summary Text (17):
To achieve the above-described objects, the present invention contemplates that membrane separation means incorporating a membrane module in a pressure vessel thereof and means for feeding fluid to be treated into this pressure vessel are integrally connected to each other, and this pressure vessel includes means for taking out permeated fluid of the module and memans for taking out thickened fluid.

Drawing Description Text (2):
FIG. 1 is a block diagram of the apparatus for reverse osmosis membrane separation showing one embodiment of the apparatus for membrane separation according to the present invention;

Drawing Description Text (3):
FIG. 2 is a view showing the appearance of an apparatus for treating liquid, wherein the apparatus according to the present invention is used;

Drawing Description Text (4):
FIG. 3 is a block diagram showing another embodiment of the apparatus for membrane separation according to the present invention; and

Drawing Description Text (5):
FIGS. 4, 5 and 6 are sectional views in explanation of the internal arrangement of the apparatus shown in FIG. 2, FIG. 5 consisting of 5(A) and 5(B) and FIG. 6 being a section taken along the line A--A in FIG. 4.

Detailed Description Text (2):
FIG. 1 is a block diagram of the apparatus for reverse osmosis membrane separation showing one embodiment of the apparatus for membrane separation according to the present invention.

Detailed Description Text (3):
A pressure vessel 1 incorporating therein reverse osmosis membranes is directly connected at one end thereof to a pump 2 for feeding liquid to be treated under pressure and provided at the other end thereof with a discharge port 3 for permeated liquid and another discharge port 4 for thickened liquid. In other words, the pressure vessel 1 is of such an arrangement that a large pressure chamber is formed in a pump discharge section, reverse osmosis membranes are mounted to the interior of this pressure chamber, and the permeated liquid discharge port and the thickened liquid discharge port are provided at the forward end of the pressure vessel.

Detailed Description Text (4):
The pump 2 is integrally formed on a motor 5 for driving the pump and is of such an arrangement that feeding means including the pump 2 and the motor 5 and membrane separation means incorporating therein the reverse osmosis membranes are directly connected to each other to thereby form a unitary structure, as shown.

Detailed Description Text (5):
In the apparatus shown in FIG. 1, liquid to be treated is delivered under pressure from a feed port 6 of the pump into the pressure vessel 1 and subjected to the membrane separation treatment.

Detailed Description Text (7):
FIG. 2 shows an appearance of a liquid treatment apparatus using the apparatus for membrane separation of substantially the same arrangement. In FIG. 2, a terminal 10 of the motor 5 is connected to a power source through a switch 11, whereby the motor 5 is started to thereby drive the pump 2. With this arangement, the liquid to be treated is passed through a valve 12, enters the pump 2 through the feed port 6, and is supplied to the reverse osmosis membranes in the pressure vessel as a power liquid. A permeated liquid, which has passed through the reverse osmosis membranes is collected in a liquid collecting pipe, not shown, and discharged to the outside of the apparatus through the permeated liquid discharge port 3. On the other hand, a thickened liquid, which has not passed through the membranes and thickened, is discharged through the thickened liquid discharge port 4.

Detailed Description Text (9):
The above-described apparatus for reverse osmosis membrane separation in this embodiment can be actuated or stopped by a very simple operation such as a manual operation by us of a power switch.

Detailed Description Text (10):
Detailed description will hereunder be given of the arrangement of the apparatus for membrane separation shown in FIG. 2, with reference to FIGS. 4 to 6.

Detailed Description Text (21):
The casing 22 is provided with an inspection window, to which is secured a plate-shaped lid 85 through bolts 86. The casing 66 is provided with similar inspection means, not shown.

Detailed Description Text (22):
Integrally provided at the center of the flange plate 43 on the side of the pressure vessel 1 is a short tube 90, into which is inserted one end of a holder 91. The other end of the holder 91 is formed into a recess 92, into which is inserted a center tube 101 of a separation membrane module 100. Engagement between the both members holds the module 100 in a predetermined position.

Detailed Description Text (23):
The module 100 is of such an arrangement that bag-shaped membranes are wound around the center tube 101. Nets and spacers such as porous plates are provided in and between the bag-shaped membranes.

Detailed Description Text (24):
The center tube 101 has a slit communicated with interiors of the bag-shaped membranes. One end of the center tube 101 is blocked and inserted into a recess 92 of the holder 91. The other end of the center tube 101 extends through an end plate 102 of the pressure vessel 1 and the forward end thereof is formed to provide the permeated liquid discharge port 3.

Detailed Description Text (25):
The module 100 has the bag-shaped membranes and the spacers. The liquid to be

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treated flows into portions of the spacers formed between the bag-shaped membranes, whereby part of the liquid is passed through the bag-shaped membranes and enters the center tube 101.

Detailed Description Text (26):
In the apparatus for membrane separation with the above-described arrangement, rotation of the motor 5 rotates the inclined plate 79 through the shafts 76 and 75, whereby the shaft 70 received in the groove 81 is reciprocated in the axial direction thereof, so that the plunger 25 makes strokes in a direction indicated by an arrow R or P. When the plunger 25 moves in the direction indicated by the arrow R, the pressure of water in the receiving chamber 26 overcomes the resiliency of the spring 33 to push the valve body 32 in P direction opposite to the direction indicated by the arrow R, whereby the water is passed through the holes 27, 28 and the window hole 36 and enters into a chamber 110 located at a position farther than the forward end of the plunger 25.

Detailed Description Text (27):
Movement of the plunger 25 in the direction indicated by the arrow P closes the passage 29, whereby the water in the chamber 110 is pressed by the plunger 25 to push the valve body 58, flows into the pressure vessel 1, holding the pressure, and further, flows into the module 100 portion. Further, part of the water is permeated through the membranes, enters the bag-shaped membranes, shortly enters the center tube 101, reaches the permeated liquid discharge port 3, and taken out as the permeated liquid. The liquid, which has not passed the membranes, is thickened, reaches the thickened liquid discharge port 4, and is extracted to the outside of the pressure vessel 1. According to the present invention, various other mechanisms, wherein the plunger 25 is reciprocated can be adopted except the mechanism, wherein the inclined plate 79 rotates to reciprocate the shaft 70 received in the groove 81 of the ring 80, whereby the plunger 25 is reciprocated as in this embodiment.

Detailed Description Text (28):
In the apparatus according to the present invention, the feeding means directly connected to the membrane separation means to form a unitary structure includes every fluid conveying means such as the blower, the compressor and the vacuum pump in addition to the pump and the motor as shown in FIGS. 1 and 2. Furthermore, the feeding means may be one, wherein the fluid to be treated is delivered under pressure from the upstream side of the membrane separation means as shown in FIGS. 1 and 2. On the contrary, the membrane separation means of a type, wherein the separated fluid is sucked at the downstream side of the membrane separation means, may be adopted.

Detailed Description Text (29):
Additionally, although a type of the pump reed not necessarily be limited in particular, it is preferable to use the plunger type, the piston type and the like, which have the quantitative characteristics. Adoption of the quantitative pumps makes it possible to satisfactorily use the same apparatus for the fluid to be treated of any permeation pressure, so that such a troublesome process that design of the apparatus cannot be initiated unless the fluid to be treated is analyzed and studied, can be omitted thus offering a great advantage in standardization of the apparatus.

Detailed Description Text (30):
Furthermore, adoption of the adapter as the means for direct connection between the membrane separation means and the driving means (the pressure vessel 1 and the pump 2 as shown in FIGS. 1 and 2) makes it possible to facilitate the exchange of the membrane separation means and the like, so that the membranes of any type can be applicable. Moreover, proper use of membranes for the sea water and the brine and exchange of the membrane separation means make it possible to utilize the same apparatus for desalting water containing various salt contents.

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Detailed Description Text (31):
The membranes installed in the apparatus for membrane separation of the type described are broadly divided into a flat plate type membrane, a tubular membrane, a spiral type membrane, a hollow filament type membrane and a fold type membrane in accordance with the shapes of elements. As the materials, in general, there may be listed cellulose acetate, polysulfone, polyethylene, polypropylene, polyacrylonitrile, polyamide, polyvinyl chloride, polyvinyl alcohol, polyimide, polyvinyl acetate and the like.

Detailed Description Text (32):
In the apparatus for reverse osmosis membrane separation according to the present invention, the quantity of desalted water per apparatus amounts to 5-8 m.sup.3 /d in the case the sea water and 17-20 m.sup.3 /d in the case of brine, for example. The recovery percentage amounts to 8-20% in the case of sea water and 8-75% in the case of brine for the treatment depending on the quality of water. Each of these values is an example, and the present invention need not necessarily be limited to this. It is preferable to provide the recycle tube when the recovery percentage exceeds 25% as in FIG. 2.

Detailed Description Text (33):
Description will hereunder be given of one embodiment of the apparatus for membrane separation for use in gas separation according to the present invention with reference to FIG. 3.

Detailed Description Text (34):
In FIG. 3, gas to be treated such as air is induced by a vacuum pump 123 driven by a motor 122, passed through strainer 121, introduced into a vessel 124 incorporating therein gas separation membranes, and treated for membrane separation. The permeated gas is exhausted through a permeated gas exhaust port, not shown, and the thickened gas is exhausted through a thickened gas exhaust port, not shown.

Detailed Description Text (35):
In the apparatus for membrane separation of gas as shown in FIG. 3 also, the membrane separation means including the vessel 124 incorporating therein the separation membranes and the driving means including the pump 123 and the motor 122 are directly connected to each other to form a unitary structure.

Detailed Description Text (36):
The apparatus for membrane separation according to the present invention is highly compact in size to facilitate the operation, so that the apparatus can be directly connected to a service water piping for use in supplying drinking water in a hotel, an office and the like. Furthermore, connection is made through a pump and a filter, so that the apparatus can be appropriately applied to a construction site and for temporary use on the field such as the military purposes and the disaster relief.

Detailed Description Text (37):
As for the apparatus for membrane separation according to the present invention, description has been made with reference to the apparatus for reverse osmosis membrane separation incorporating therein the reverse osmosis membranes and examples. However, the apparatus for membrane separation according to the present invention need not necessarily be limited to this, and, it is needless to say that the present invention is appropriately applicable to all of the apparatuses each incorporating therein the membranes having the selective permeation function such as the ultrafiltration membranes and precision filtration membranes in addition to the reverse osmosis membranes.

Detailed Description Text (38):

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As has been detailedly described hereinabove, the apparatus for membrane separation according to the present invention is constructed such that the membrane separation means including the vessel incorporating therein the membranes and the driving means for delivering the fluid to be treated to the membrane separation means are directly connected to each other to form the unitary structure, whereby the apparatus is rendered simplified in arrangement, highly compact in size and light in weight and reduced in the member of component pasts to a considerable extent. Therefore, the transportation and maintenance are highly simplified and the operation is facilitated. Furthermore, the complicated piping works and the installation of instrumentation are obviated, and labor therefore is reduced to a considerable extent. Moreover, the apparatus is very high in reliability.

Detailed Description Text (39):
Thus, the apparatus for membrane apparatus as a whole is small-sized, requires the small installation area and facilitates the manufacture, transportation, installation, control, operation and the like, so that the apparatus can be applied to the very wide fields.

CLAIMS:

1. An apparatus for membrane separation, comprising:

a module of membranes for permeatingly treating fluid to be treated;

a pressure vessel incorporating therein said module;

means for taking out the module-permeated fluid and means for taking out the thickened fluid, which are provided in said pressure vessel;

means for feeding the fluid to be treated under pressure into said pressure vessel, said feeding means being connected to said pressure vessel to form a unitary structure and including a plunger type pump and a motor with a shaft for driving the pump, said pump including a casing, a rotary shaft situated inside the casing and connected to the shaft of the motor, an inclined plate provided on said rotary shaft and inclined to a plane normal to the axis of said rotary shaft, a ring concentrical with said rotary shaft on the side opposite to the motor, a ring shaped groove with a smooth wall formed inside the ring, a plurality of plungers slidably situated in the casing and having spherical forward ends situated in the ring shaped groove, and a plurality of coil springs for pressing said plungers such that the forward ends of the plungers are pushed into the ring shaped groove.

2. An apparatus for membrane separation as set forth in claim 1, wherein said feeding means and said pressure vessel are connected to each other through bolts.

3. An apparatus for membrane separation as set forth in claim 1, wherein said pump and said motor are connected to each other through bolts.

4. An apparatus for membrane separation as set forth in claim 1, wherein said casing of the pump is secured to said pressure vessel through bolts.

5. An apparatus for membrane separation as set forth in claim 4, wherein a casing of a connector is interposed between said casing of the pump and said motor and said connector casing is secured to said motor and said pump casing through bolts, respectively.

6. An apparatus for membrane separation as set forth in claim 5, wherein said membranes are reverse osmosis membranes.

7. An apparatus for membrane separation as set forth in claim 1, wherein said membrane module has a center tube and bag-shaped membranes wound around said center

tube.

8. An apparatus for membrane separation as set forth in claim 7, wherein said center tube extends through an end plate of the pressure vessel and projects to the outside of the pressure vessel.

9. An apparatus for membrane separation as set forth in claim 1, wherein said membrane are reverse osmosis membranes, precisison filtration membranes or ultrafiltration membranes.

10. An apparatus for membrane separation as set forth in claim 1, wherein means for returning thickened fluid taken out of the pressure vessel to the pressure vessel is provided.

11. An apparatus for membrane separation as set forth in claim 1, wherein an opening for inspecting the interior of said pump casing is provided on said pump casing and a lid is secured to said opening through a bolt.

12. An apparatus for membrane separation as set forth in claim 1, wherein a plurality of plungers are arranged in a circumferential direction.

13. An apparatus for membrane separation, comprising:

a module of membranes for permeatingly treating fluid to be treated;

a pressure vessel incorporating therein said module, said pressure vessel having means for taking out module-permeated fluid and means for taking out thickened fluid; and

pump and motor means for feeding the fluid to be treated under pressure into said pressure vessel, said pump and motor means being connected directly to said pressure vessel to form a linear unitary structure, said pump and motor means including a plunger type pump for feeding the fluid to be treated under pressure into said pressure vessel, said pump having a rotary shaft therein and being connected directly to said pressure vessel, a motor having a rotary shaft connected to the rotary shaft of said pump, and casings for enclosing said pump and motor to form a linear unitary structure.

14. An apparatus according to claim 13, wherein said pump comprises:

a plate provided on said rotary shaft of the pump, said plate being inclined relative to a plane normal to the axis of said rotary shaft;

a ring secured to the plate at a side opposite to the motor to be concentric with said rotary shaft of the pump, said ring having a ring-shaped groove with a smooth wall;

a plurality of plungers slidably situated in the casing, each plunger having a spherical forward end situated in the ring-shaped groove of the ring; and

a plurality of coil springs attached to the respective plungers for pushing the plungers toward the ring-shaped groove so that when the inclined plate is rotated by means of the motor, the plungers are moved back and fourth inside the casing of the pump to send fluid to the pressure vessel.

15. An apparatus according to claim 14, wherein each plunger includes a through hole therein extending along the longitudinal direction thereof and having an inlet and outlet to permit fluid flowing from the inlet to the outlet through the hole.

16. An apparatus according to claim 15, wherein said pump further comprises:

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a plurality of first valves connected to the respective plungers at the outlet thereof, each first valve including a first valve box with a plurality of first openings, a first valve body situated inside the first valve box, and a first valve spring situated inside the first valve box to urge the first valve body toward the outlet so that only when the plunger is moved toward the motor, fluid passes through the first valve; and

a plurality of second valves connected to the casing to permit communication between the respective first valves and the pressure vessel, each second valve including a second valve box with a plurality of second openings, a second valve body situated inside the second valve box, and a second valve spring situated inside the second valve box to urge the second valve body toward the plunger so that only when the plunger is moved toward the pressure vessel, fluid passes through the second valve and flows to the pressure vessel.

17. An apparatus for membrane separation, comprising:

a module of membranes for permeatingly treating fluid to be treated;

a pressure vessel incorporating therein said module;

means for taking out the module-permeated fluid and means for taking out the thickended fluid, which are provided in said pressure vessel;

means for feeding the fluid to be treated under pressure into said pressure vessel, said feeding means being connected to said pressure vessel to form a unitary structure and including a plunger type pump and a motor with a shaft for driving the pump, said pump including a casing, a rotary shaft situated inside the casing and connected to the shaft of the motor, an inclined plate provided on said rotary shaft and inclined to a plane normal to the axis of said rotary shaft, a plurality of plungers slidably situated in the casing and having forward ends abutting against the inclined plate, and a plurality of coil springs for pressing said plungers such that the forward ends of the plungers are pushed onto the inclined plate.